Reforestation Study Analysis

Report Prepared for:
Oregon Department of Forestry,
Compliance Monitoring Program

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ABSTRACT

From October 2023 to May 2024, the Oregon Department of Forestry completed a study on reforestation following clearcuts on private timberlands, as required by Oregon's Forest Practices Act. The study estimated compliance with reforestation stocking density requirements by conducting field surveys to assess free to grow stocking density on a sample of harvest units and comparing these estimates to those required by the Forest Practices Act rules. The study population was all clearcuts of at least two acres completed in 2016 and 2017 with private industrial and private nonindustrial landowners. A random sample of harvest units was drawn from the Forest Activity Electronic Notification database, screened for harvest completion along with other suitability criteria, and landowners were contacted for participation in the study. A total of 39 private industrial and 25 private nonindustrial harvest units were surveyed, with compliance estimated at 92.3% for private industrial landowners and 76% for private nonindustrial landowners. Overall compliance for the study population was estimated at 89.4%. To account for uncertainty in results due to landowner nonresponse and access refusal, a sensitivity analysis was conducted to quantify the impact of these factors across a range of theoretical compliance values.

INTRODUCTION

From October 2023 to May 2024, The Oregon Department of Forestry (ODF) conducted Reforestation Compliance Monitoring according to the Reforestation Compliance Monitoring Study Plan and Protocol (ODF 2023; Appendix A) on Private Industrial (PI) or Private Nonindustrial (PNI) timberlands following commercial forest operations per the rules in Oregon's Forest Practices Act (FPA). Reforestation is considered, "an essential factor in assuring continuous growing and harvesting of forest tree species, considering landowner objectives and consistent with the sound management of timber and other forest resources" (OAR 629-610-0000 (1)). This study collected field data at a randomly drawn sample of harvest units harvested in 2016 and 2017 that required reforestation and used the data to estimate the percent compliance with OAR 629-610-0040(4) which requires an established a free to grow (FTG) stand of trees that meets or exceeds the minimum stocking level required by OAR 629-610-0020. The study population was defined as all clearcut operations completed in 2016 or 2017 between 2 and 120 acres, had Private Industrial (PI) or Private Nonindustrial (PNI) landowner types, were accessible by road, and did not include a plan for alternate practice that altered reforestation requirements, a land use conversion, or change of landowner.

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METHODS

Sample draw

The sample of harvest units was obtained from the Forest Activity Electronic Notification System (FERNS). First, notifications were filtered to clearcuts greater than two acres in size that were scheduled for completion in 2016 or 2017. Notifications were then stratified by landowner type (PI or PNI) and two additional rounds of screening were conducted to infer harvest completion prior to contacting landowners. Next, ODF staff conducted desktop prescreening to remove unsuitable notifications from FERNS data. Reasons for removal included duplicate notifications, operations less than 2 acres, and burn areas. This resulted in a sample of 8,082 notifications (Table 1), from which a random draw of 120 PI and 409 PNI notifications were obtained for desktop screening with remote imagery to visually assess harvest completion. The number of notifications for remote imagery screening was selected to obtain the target overdraw sample size and informed by observed harvest completion rates during prior compliance monitoring studies. After remote imagery screening, an overdraw sample of 53 PI and 170 PNI notifications were obtained for contacting landowners to confirm harvest unit suitability and obtain land access permission, following recommendations of the Reforestation Study Plan (Table 2; ODF 2023; Appendix A). This process resulted in a sample of 39 PI and 25 PNI harvest units surveyed for reforestation. Finally, a subset of 4 PI and 4 PNI units were surveyed a second time at exact replicate plots to ensure consistency in field survey methods and evaluate measurement error.

Data collection

Compliance with reforestation stocking was evaluated on a harvest unit basis using a fixed-radius plot sampling approach, detailed in ODF (2023; Appendix A). Within each harvest unit, $1/50^{th}$ acre circular plots (16.7-foot radius) were established and surveyed for free-to-grow (FTG) trees (Figure 1). Trees that meet free to grow status are defined as "vigorous, healthy, and dominant over undesired competing vegetation." ODF Monitoring Unit staff developed a field definition for FTG determination based on the ODF State Forests Stocking Surveys protocol that was established in accordance with FPA rules OAR 629-610-000 through 629-610-0100 (ODF, unpublished). Trees were classified as FTG or not FTG based on their status during the survey, determined by criteria including vegetation competition, tree density, tree species composition, and survival and vigor. An example of vegetation competition and tree density is depicted in Figure 2. In this context, a tree was classified as FTG if it received ample sunlight and visibly outcompeted surrounding vegetation, and as not FTG if it was entirely overshadowed by vegetation. Borderline cases where some light blockage or competition was present could still be classified as FTG based on the remaining criteria. Surveyors were trained on this protocol and provided reference documents to ensure consistent FTG determinations. For clarity, only trees designated as 'crop species' were counted (Table 3).

When circular plots were within 20 feet of a road or the harvest unit boundary, an offset procedure was applied to attempt to move the plot within 50 feet of the original location. Plots

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were not surveyed when greater than 1/3 of the plot was unharvested, unplantable (e.g., bare rock), or within a riparian management area. Trees that met FTG criteria were tallied by species and size class (seedling (< 1 in DBH), sapling or pole (1 to 10 in DBH), and sawtimber (11 in DBH and greater), within the survey plot. DBH was measured and recorded for trees larger than 10 inches DBH.

Data handling

Tree count and diameter data were converted to seedling equivalents (SEQ) per plot and per acre using conversion factors defined by OAR 629-610-0020. SEQ data were summarized at the plot and harvest unit scale. Replicate quality assurance (QA) plots were paired with initial surveys for analysis of measurement error. FERNS notification and suitability data were summarized by landowner type to calculate proportions of suitable harvest units, population size, and rates of nonresponse and access refusal.

Compliance determination

Each harvest unit was determined to be either as in compliance or in noncompliance (a binary response) based on the required trees per acre (TPA) as expressed in SEQ. OAR 629-610-0020 defines the "minimum tree stocking standard" based on the appropriate Cubic Foot Site Class for the harvest unit. Compliance was determined using the lower bound of a one-sided tolerance interval. Tolerance intervals were calculated using the 'tolerance' package (Young and Cheng 2024) for the statistical software R (R Core Team 2024) with a Poisson distribution. The tolerance interval approach provided an estimate of the minimum stocking level for at least 80% of the harvest unit with 95% confidence. For instance, if the lower bound of the tolerance interval estimated 200 TPA, it can be inferred with 95% confidence that at least 80% of the unit is stocked to at least 200 TPA.

After determining compliance or noncompliance for each harvest unit, total compliance by and across landowner type was estimated using average compliance from the sample. Compliance across strata was calculated using strata weights derived from population estimates. Uncertainty was quantified using 95% two-sided binomial tolerance intervals for 99% of the population, indicating the proportion of compliance that would be expected for at least 99% of harvest units with 95% confidence. For instance, if the binomial tolerance interval extended from 75% to 95%, it can be inferred with 95% confidence that compliance is between these values for at least 99% of the study population.

Additional error analyses

Two sources of error were quantified for potential effect on compliance: measurement error and landowner nonresponse. A high degree of measurement error could lead to unreliable compliance determination when stocking was near the TPA requirement. We chose to examine the distribution of measurement error, parameterized as the differences between tree tally counts, expressed in SEQ, at the paired QA replicate survey locations. First, the assumption that measurement error is normally distributed about zero was tested by examining the distribution of

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measurement error across all QA replicates. Second, the potential for measurement error to affect the reliability of compliance determination was quantified by comparing variances of measurement error and the observed data.

Nonresponse occurred during the sample draw process, where some landowners did not respond to phone calls, emails, and letters that invited participation in the study. Additionally, some landowners declined to participate by directly refusing land access for surveys. It is unknown if actual compliance for the nonresponse and access refusal groups differs from compliance of surveyed units, so all estimates of compliance exclude these groups. The potential effect of nonresponse and access refusal was quantified through a sensitivity analysis, which examines the effect of changing input values to quantify uncertainty in results. Since compliance rates for the nonresponse and access refusal groups were unknown, theoretical compliance values for these groups were applied in the analysis, ranging from 0% to 100%. It was assumed that the proportion of suitable harvest units for the nonresponse and access refusal groups followed the same distribution as observed among respondents.

RESULTS

Sample draw

A total of 64 suitable harvest units were surveyed (39 PI, 25 PNI), with an average of 24 plots per unit (range 18 – 28). All units in the PNI stratum had a 200 TPA minimum stocking requirement, and the PI stratum included 31 units with a 200 TPA minimum and eight units with a 125 TPA minimum. A total of 1,533 unique survey plots were sampled, 199 of which were moved to a suitable location within 50 feet from the original location using the offset protocol defined in ODF (2023; Appendix A). One PI harvest unit was surveyed but later considered unsuitable and removed from the study as the operation reduced stocking for greater than 120 acres and included a combination of clearcut and overstory removal.

For PI landowners, the proportion of suitable harvest units was high throughout the sample draw process (Table 1), and nonresponse and access refusal were relatively infrequent (Table 2). This resulted in successful surveys for 73.5% of the initial sample overdraw. For PNI landowners, the large sample overdraw was necessary to obtain a sufficient sample of suitable harvest units. Remote imagery screening removed 37.1% of candidates, and 57.6% were found to be unsuitable after landowner contact. Nonresponse and access refusal also substantially impacted sample size. Nearly half of landowners that were contacted were nonrespondents (48%), and in 22% of cases nonresponse was likely due to incorrect or outdated contact information in FERNS, observed by disconnected phone lines or mail that was returned to sender. Additionally, 14 PNI landowners indicated approval during initial contact but did not complete paperwork and were ultimately considered nonrespondents.

Strata weights for overall compliance were determined using observed suitability rates from desktop remote imagery screening and landowner contact, combined with the number of

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notifications in FERNS. The total study population was estimated at 4,277 harvest units (95% CI 3,488 – 5,064; Table 1); 82.1% PI units and 17.9% PNI units.

FTG stocking and measurement error

Free-to-grow stocking, evaluated as SEQ per plot, was unimodally distributed with relatively high variability and a positive skew (Figure 3). Mean FTG stocking was above TPA requirements at 296 SEQ per acre (SD: 149) for PI units with 125 TPA requirement, 360.5 (SD: 160) for PI units with 200 TPA requirement, and 330.5 (SD: 168) for PNI units with 200 TPA requirement. The relatively high standard deviations can be partially attributed to logistical constraints on plot size. For example, at a stocking level of 200 trees per acre, the expected count would be 4 FTG seedlings spaced at approximately 14.8 feet. Douglas fir was the dominant species encountered among FTG trees, accounting for over 80% of overall FTG stocking (Table 4), followed by western hemlock (11.5%) and ponderosa pine (2.5%). Since at least 90% of FTG stocking was composed of Douglas fir and western hemlock, there were only minor differences in species composition between landowner types.

There was no clear evidence that measurement error biased or materially influenced the reliability of compliance estimates. A comparison of the 195 exact replicate QA plots conducted at 8 harvest units revealed that measurement error followed an approximately normal distribution centered around zero, suggesting consistency in tree counts and FTG classification (Figure 4). Additionally, the magnitude of measurement error variance was only 3% of the variance observed in the tree tally data in SEQ, indicating that variation in stocking levels at plot locations was the primary driver for stocking estimates and compliance determination.

Free-to-grow stocking was summarized by harvest unit using the lower bound of one-sided tolerance intervals with 80% population coverage and 95% confidence, along with mean stocking estimates with 95% Poisson confidence intervals (Figure 5). Tolerance interval lower bounds were consistently 5 – 10% lower than mean stocking estimates. The 95% Poisson confidence intervals surrounding mean stocking estimates were relatively wide, with a mean distance of ± 69.6 SEQ per acre from the stocking estimate.

Compliance rates

Overall compliance of the study population was estimated at 89.4% (Table 5). This proportion of the study population is expected to be stocked at or above TPA requirements for at least 80% of each harvest unit. The two-sided binomial tolerance interval estimated that the expected proportion of harvest unit compliance for at least 99% of the study population with 95% confidence was between 76.3% and 99%.

Compliance for the PI landowner type was estimated to be 92.3% (Table 5). Compliance for PI units with a 125 TPA requirement was 100%, and compliance for PI units with a 200 TPA requirement was 90.2%. PNI units all had a 200 TPA requirement and compliance was estimated at 76%. During surveys, ODF staff noted that PNI sites with low stocking were associated with sparse planting, high mortality, competition with hazel and blackberry, or unplanted plots.

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Error due to nonresponse and access refusal

Nonresponse and access refusal were common during the sample draw process (Table 2) and could increase uncertainty in compliance estimates. Nonresponse or access refusal accounted for 15.1% and 65.2% of the sample overdraw for PI and PNI units, respectively. Although nonresponse and access refusal were frequent among PNI landowners, 57.6% of harvest units from the sample overdraw were unsuitable. This reduced the potential effect of nonresponse and access refusal for PNI units from 65.2% to 42.5%. Therefore, nonresponse and access refusal were estimated to influence 42.5% of the PNI population, 15.1% of the PI population, and 20% of the combined study population.

The sensitivity analysis revealed that the potential influence of nonresponse and access refusal was considerably less for PI units compared to PNI units (Figure 6). Since PI units composed 82% of the total population, the effect of nonresponse and access refusal on the population was primarily driven by the impact on units with PI landowners. For instance, in a scenario where compliance for the nonresponse and access refusal groups was 20% lower than the observed values, total PI compliance decreased by 2.8%, PNI compliance by 8.5%, and total population compliance by 3.8%. In the most extreme scenario with 0% compliance for the nonresponse and access refusal groups, PI compliance decreased by 12.8%, PNI compliance by 32.4%, and total population compliance by 16.3%. In scenarios where compliance of the nonresponse and access refusal groups aligned more closely with observed estimates, the effects were considerably more modest (Figure 6).

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Table 1. Results from the FERNS sample draw process, the observed proportions of suitable units, and estimated study population size.

Landowner type	Notifications after prescreening	Imagery screening suitability	Contact suitability	Population estimate (95% CI)
PI	5,172	78.3%	86.7%	3,511 (2,990 – 4,031)
PNI	2,910	62.1%	42.4%	766 (498 – 1,033)
Total	8,082	75.5%	78.8%	4,277(3,488 – 5,064)

Table 2. Number of notifications drawn from the FERNS database and the result of landowner contact. Values in parentheses indicate the number of notifications where the contact information may have been incorrect.

Landowner type	Sample overdraw	Nonresponse	Permission refused	Confirmed unsuitable	Surveyed
PI	53	7 (1)	1	6	39
PNI	170	82 (18)	29	34	25
Total	223	89 (19)	30	40	64

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Table 3. Crop and non-crop tree species designation for inclusion in the Reforestation Study.

Crop species	**Non-crop species**
Alaska yellow-cedar	Bigleaf maple
California red fir	Black cottonwood
California redwood	California laurel (myrtle)
Douglas fir	Giant chinquapin
Western hemlock	Oregon ash
Engelmann spruce	Oregon white oak
Grand fir	Pacific madrone
Incense cedar	Red alder
Jeffrey pine	Tanoak
Lodgepole pine	
Mountain hemlock	
Noble fir	
Ponderosa pine	
Port-Orford-cedar	
Western redcedar	
Sitka spruce	
Subalpine fir	
Sugar pine	
True fir (unknown fir)	
Western hemlock	
Western larch	
Western red cedar	
Western white pine	
White fir	

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Table 4. Observed composition of crop tree species by landowner type, calculated using seedling equivalent.

Species	PI	PNI	Overall
Douglas fir	77.34%	86.61%	80.80%
Grand fir	0.94%	0.83%	0.90%
Incense fir	0.31%	0.21%	0.27%
Noble fir	0.00%	0.41%	0.15%
Unknown fir	2.02%	0.30%	1.38%
True fir, total	**3.27%**	**1.75%**	**2.70%**
Englemann spruce	0.08%	0.00%	0.05%
Sitka spruce	0.01%	0.73%	0.28%
Unknown spruce	0.04%	0.00%	0.03%
Spruce, total	**0.14%**	**0.73%**	**0.36%**
Western red cedar	0.19%	1.01%	0.50%
Port-Orford-cedar	0.24%	0.07%	0.18%
Cedar, total	**0.44%**	**1.08%**	**0.68%**
California redwood	0.12%	0.00%	0.08%
Ponderosa pine	3.92%	0.04%	2.47%
Western hemlock	12.61%	9.80%	11.56%
Western larch	2.16%	0.00%	1.35%

Table 5. Estimated compliance with reforestation stocking requirements (OAR 629-610-0020), calculated using one-sided Poisson tolerance intervals with 80% population coverage and 95% confidence. The two-sided 95% binomial tolerance intervals were calculated with 99% population coverage and 95% confidence.

Landowner type	TPA requirement	Harvest units	Compliance estimate	95% binomial tolerance interval
PI	125	8	100%	100% – 100%
PI	200	31	90.3%	76.6% – 100%
PI, total	-	39	92.3%	80.9% – 100%
PNI	200	25	76%	55.2% – 94.8%
Overall	-	64	89.4%	76.3% – 99.1%

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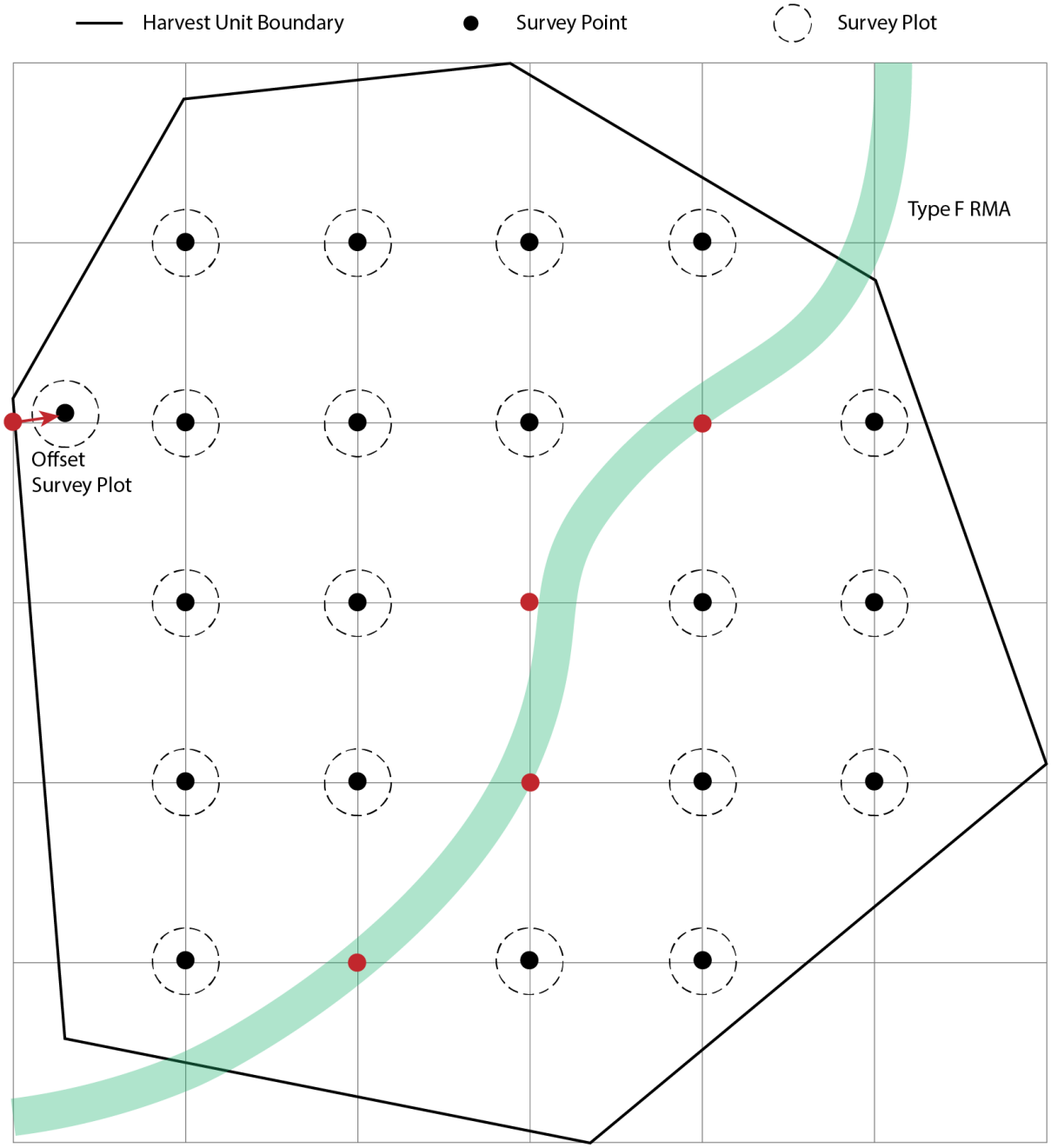

Figure 1. Conceptual diagram of a harvest unit survey area. Red dots indicate Survey Points that would be unsuitable for surveying.

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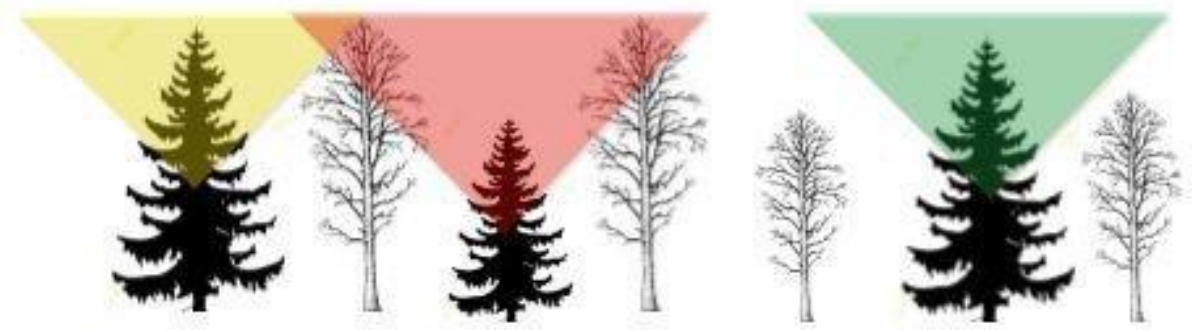

Figure 2. Conceptual diagram of free to grow (green), borderline free to grow (yellow), and not free to grow (red) trees based on tree density and competition of surrounding vegetation. Source: ODF (unpublished)

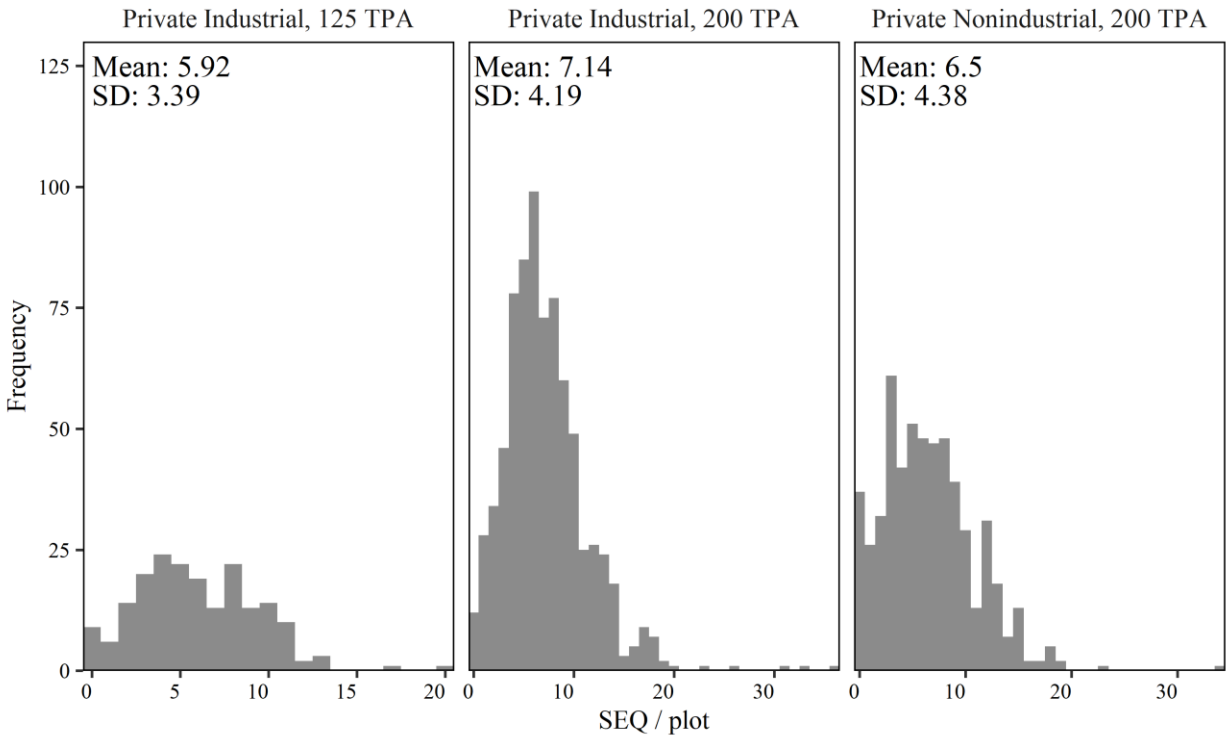

Figure 3. Distributions of FTG tree count data by landowner type and tree per acre (TPA) stocking requirements, expressed in seedling equivalents (SEQ).

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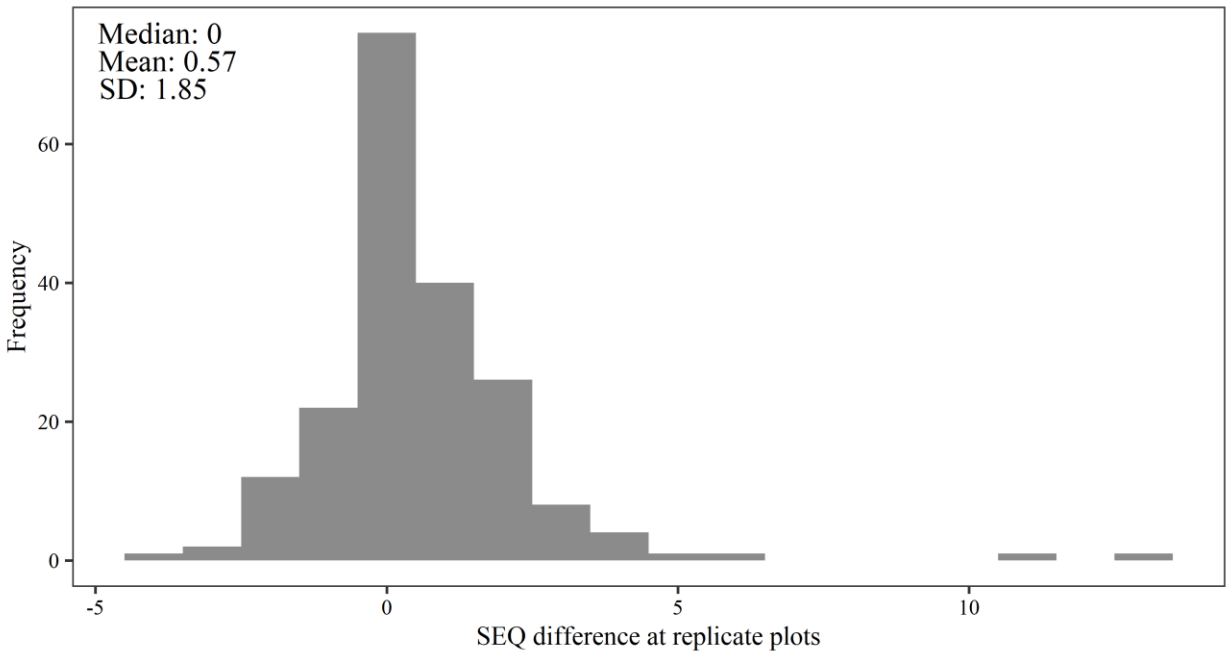

Figure 4. Distribution of the difference between initial and exact replicate plot FTG tree count surveys, expressed in seedling equivalents (SEQ).

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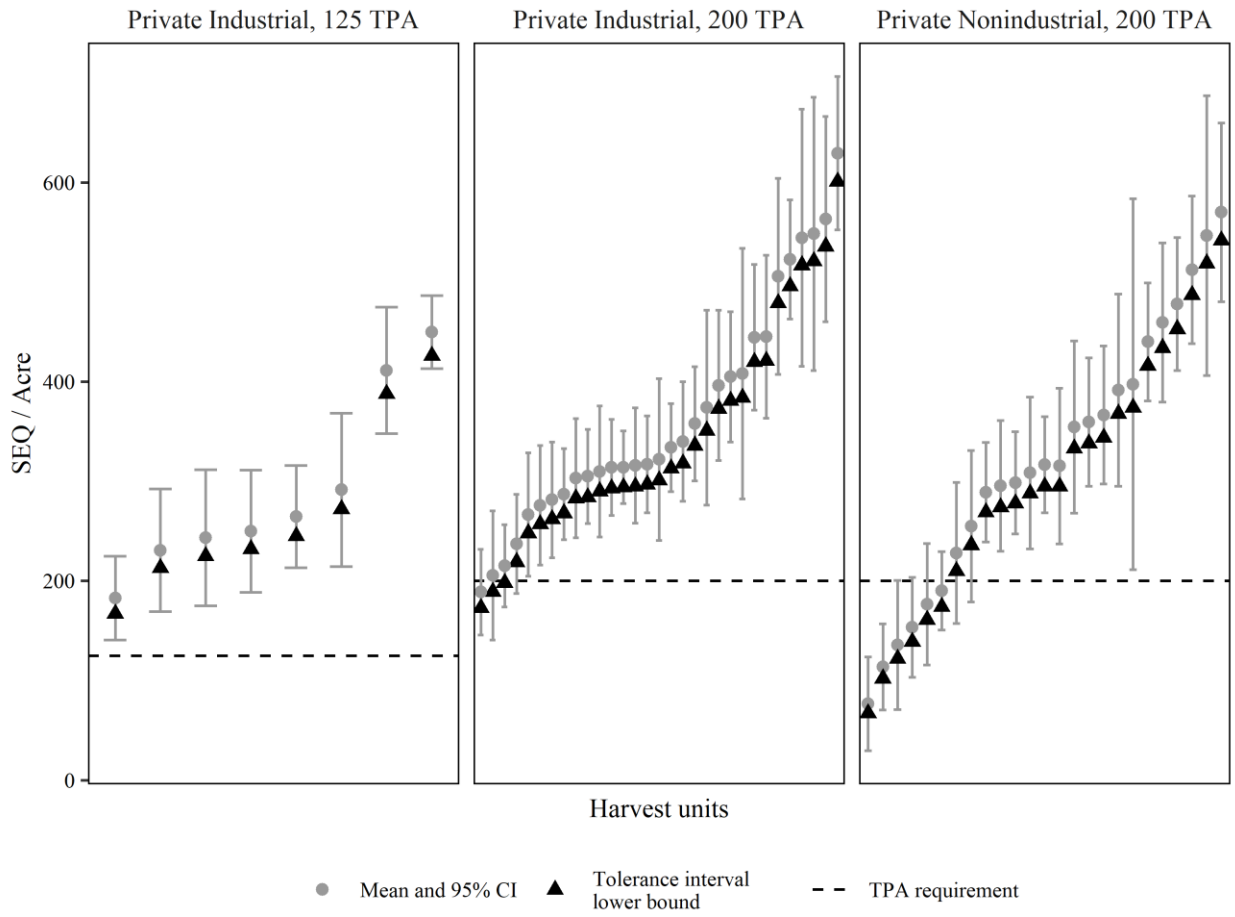

Figure 5. Estimated harvest unit FTG stocking and tree per acre (TPA) minimum requirements, expressed in seedling equivalents (SEQ). Grey points and error bars are mean stocking estimates with associated 95% Poisson confidence intervals, and black triangle points are the minimum estimated stocking with 80% harvest unit coverage and 95% confidence.

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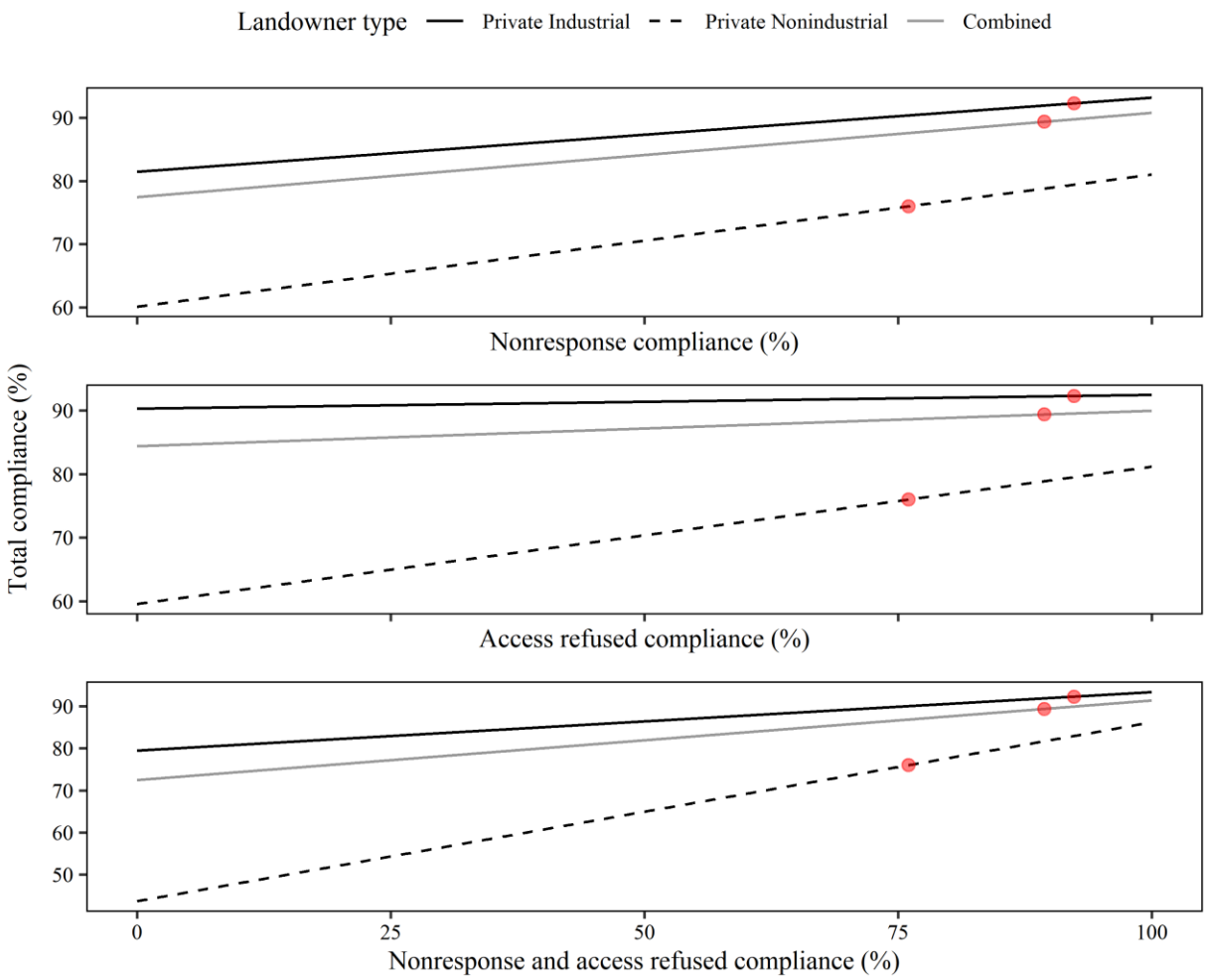

Figure 6. Sensitivity analysis results showing the influence of theoretical compliance values (x-axis) for nonresponse and access refusal groups on total compliance estimates by landowner type (y-axis). Lines represent estimated compliance across the range of theoretical compliance values, and red points indicate observed compliance estimates. The top panel displays results for the nonresponse group, the middle panel for the access refused group, and the bottom for both groups combined.

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APPENDIX A

Reforestation Compliance Monitoring

Study Plan and Protocol

JUNE 30, 2023

OREGON DEPARTMENT OF FORESTRY

Contents

Definitions

Note: The definitions that are derived from the Forest Practices Rules are current as of June 2023. Definitions may change with ongoing rule changes.

Clearcut: For purposes of this document, a “Harvest Type 1” and “Harvest Type 3” under the Forest Practice Administrative Rules (OAR 629-600-0100 (32), (34)). In FERNS, these types of activities are classified as “Clearcut/Overstory Removal”.

Dying or recently dead tree: "Dying or recently dead tree" means a tree with less than ten percent live crown or a standing tree which is dead but has a sound root system and has not lost its small limbs. Needles or leaves may still be attached to the tree. (OAR 629-600-0100 (18)).

E-Notification: The formal name used by the State of Oregon for the Forest Activity Electronic Notification System (FERNS).

FERNS: Forest Activity Electronic Notification System. The online tool used to notify the Oregon Department of Forestry when forest operations are planned. FERNS replaces earlier paper-based notification methods.

Harvest Type 1: An operation that requires reforestation but does not require wildlife leave trees. A harvest type 1 is an operation that leaves a combined stocking level of free to grow seedlings, saplings, poles, and larger trees that is less than the stocking level established by rule of the board that represents adequate utilization of the productivity of the site (OAR 629-600-0100 (32)). See OAR 629-610-0020 for applicable stocking levels.

Harvest Type 3: An operation that requires reforestation and requires wildlife leave trees. This represents a level of stocking below which the size of operations is limited under ORS 527.740 and 527.750 (OAR 629-600-0100 (34)).

Harvest Unit Boundary: A polygon drawn by ODF identifying the area to be sampled for reforestation. This polygon defines the area that was part of the harvest treatment and excludes riparian management areas. This polygon may be equal to or be a subset of the area included in the FERNS Unit.

Landowner: Any individual, combination of individuals, partnership, corporation, or association of whatever nature that holds an ownership interest in forestland, including the state and any political subdivision thereof (OAR 629-600-0100 (43)). For the purposes of this document, the term is also used to describe any manager, agent, or other person designated by the landowner to have authority to grant permission to access the Survey Area. The ODF monitoring unit uses the FERNS landowner identification fields to make initial determinations of ownership.

Landowner Type: Description of landowner business characteristics. In FERNS, Type is self-reported, and includes 1. Partnership/Corporation/Industrial Forest Landowner, 2. Individual/Private Non-Industrial Landowner, and 3. several government and nonprofit classes. For this study, these are summarized as 1. Private Industrial (PI), 2. Private Nonindustrial (PNI), and 3. Other (OTH) classes, respectively.

Live Tree: A tree that has 10 percent or greater live crown (Definitions 629-600-0100(40))

Notification: A Notification to the State Forester when performing forest operations, as described in ORS 527.670. Notifications are performed using FERNS. Synonyms include Notification of Operation, or NOAP.

Riparian Management Area: An area along each side of specified waters of the state within which vegetation retention and special management practices are required for the protection of water quality, hydrologic functions, and fish and wildlife habitat (OAR 629-600-0100 (63)). Riparian management area widths are given in the following table (OAR 629-635-0310).

	Type F	Type SSBT	Type D	Type N
Large	100 feet	N/A	70 feet	70 feet
Medium	70 feet	80 feet	50 feet	50 feet
Small	50 feet	60 feet	20 feet	

Saplings & Poles: Trees with diameter at breast height (DBH) greater than one inch, and less than 10 inches. *(Forest Practices Notes #2 – Reforestation. December 1994, pg.3)*

Snag: a tree which is dead but still standing, and that has lost its leaves or needles and its small limbs. (Definitions 629-600-0100(70).

Sound Snag: a snag that retains some intact bark or limb stubs (Definitions 629-600-0100(71).

Survey Plot: A circular sampling location centered on a Survey Point with a 16.7-foot radius where free to grow tree counts and species are recorded.

Survey Point: Potential plot locations. These are a grid of equidistant points within each Harvest Unit Boundary.

Trees: for the purpose of determining Seedling Equivalents of residual trees left after a harvesting operation, "Trees" are trees with a minimum 11-inch diameter. *(Forest Practices Notes #2 – Reforestation. December 1994, pg. 3)*

Type F Stream: A stream with fish use, or both fish use and domestic water use (OAR 629-600-0100 (85)).

Unit: An operation area submitted on a notification of operation that is identified on a map and that as single continuous boundary. Unit is used to determine compliance with ORS 527.676 (down log, snag, and green tree live retention), 527.740 and 527.750 (harvest type 3 limitation), and other forest practice rules (OAR 629-600-0100 (87)). For purposes of this study, this corresponds to the clearcut harvest unit as drawn by a notifier in the E-Notification or FERNS online forest operation notification system.

Background & Scope

Reforestation is required after commercial forest operations within the purview of the Oregon Forest Practices Act (FPA), and is considered "an essential factor in assuring continuous growing and harvesting of forest tree species, considering landowner objectives and consistent with the sound management of timber and other forest resources" (OAR 629-610-0000 (1)). The Reforestation Compliance Monitoring Study Plan was developed to monitor reforestation on privately-owned forests. The study also supports Oregon Department of Forestry's (ODF) agency goals that include providing data to the Oregon legislature and Board of Forestry on FPA compliance, along with training, education, and outreach. The Reforestation Study was designed to assess compliance with the following subset of FPA rules from Division 610:

1) OAR 629-610-0040 (3): The landowner shall complete planting or seeding within 24 months unless a plan for an alternate practice for natural reforestation has been approved by the State Forester.

2) OAR 629-610-0050: Harvest units were restocked with tree species acceptable for reforestation.

3) OAR 629-610-0040 (4): By the end of the sixth full calendar year, the landowner shall have established a free to grow (FTG) stand of trees which meets or exceeds the minimum stocking level required by OAR 629-610-0020.

This study can estimate the percentage of harvest units in compliance with the above FPA rules for all clearcut operations that require planting for reforestation between 2 and 120 acres in size with private industrial (PI) and private nonindustrial (PNI) landowner types. Compliance with OAR 629-610-0040 (3) will be determined by evidence of planting, seeding will not be considered. This study will not evaluate rule compliance in riparian management areas (RMA).

Parameters of Interest

Compliance with the FPA rules of interest (OAR 629-610-0040 (3), OAR 629-610-0050, OAR 629-610-0040 (4)) is determined with two independent study designs and survey efforts: planting timeliness and FTG stocking surveys. Since the designs are independent, they can be conducted concurrently or separately, and results from one will not affect the other. First, planting timeliness (OAR 629-610-0040 (3)) and reforestation with acceptable species (OAR 629-610-0050) will be examined for a sample of harvest operations that were completed 24 to 36 months prior to study surveys. Second, FTG reforestation stocking (OAR 629-610-0040 (4)) will be assessed on a separate sample of harvests that were completed six to seven calendar years prior to FTG stocking surveys.

Planting Timeliness

Planting timeliness surveys will determine compliance with OAR 629-610-0040 (3) through visual inspection of the harvest unit. During visual inspection, surveyors will confirm replanting in suitable areas and record the species planted. Planting data will be collected using either a systematic random sample at Survey Points or a visual inspection of the entire unit. Harvest units will be considered in

compliance if planting was completed with acceptable species throughout the harvested area that is suitable for planting at the time of surveying.

Free To Grow Stocking

Free to grow stocking surveys will assess compliance with OAR 629-610-0040 (4). Harvest unit compliance will be determined based on FTG tree count data collected from a systematic random sample of fixed-area plots within each harvest unit. Tree counts from survey plots will be converted to trees per acre (TPA) and compared to required minimum stocking levels described in OAR 629-610-0020. Minimum stocking requirements will depend on the Cubic Foot Site Capability Class (CFSC) of each harvest unit. Compliance will be determined using one-sided tolerance intervals that estimate the minimum stocking for at least 80% of the harvest unit, per "well-distributed" criteria for minimum stocking (OAR 629-610-0000 Guidance). When the lower bound of the tolerance interval indicates that TPA meets or exceeds minimum stocking requirements, the unit will be considered in compliance.

Sampling Design

The planting timeliness and FTG stocking surveys will be completed for a random sample of harvest units selected from the Forest Activity Reporting and Notification System (FERNS) database, stratified by landowner type. Since the FERNS database does not include all necessary information to determine if a harvest unit is within the sample population and landowners must grant permission for access, a sample overdraw is required for each stratum to ensure sufficient sample sizes.

The sample draw process should proceed as follows:

1. Filter FERNS notifications using suitability criteria.
2. Randomize the filtered list of candidate notifications.
3. Conduct the sample overdraw by proceeding down the randomized list while screening each notification for harvest completion.
4. When screening indicates that harvest was completed within the desired timeframe, the notification will be added to the sample overdraw list.
5. Sample overdraw and screening is complete when the desired overdraw sample size is met.

Harvest Unit Selection

Sample Draw

The FERNS database will be used to generate lists of candidate harvest units that are likely to trigger reforestation requirements. Harvest notifications will be randomly drawn from FERNS after filtering notifications for the following suitability criteria:

Survey Type	Attribute	Suitability Criteria
Planting timeliness & free to grow stocking	Activity type	Clearcut
	Operation size	2 – 120 acres
	Private landowner type	PI or PNI
Planting timeliness	Harvest completion date	24 to 36 months prior to survey dates
Free to grow stocking	Harvest completion date	Six to seven calendar years prior to survey dates

After filtering for suitability criteria, FERNS notifications will be randomly ordered into a list. This list of candidate harvest notifications will likely include units that do not meet population criteria for the study. For example, harvests may not have occurred before the reported harvest completion date or there is an alternative plan for reforestation. The candidate list may also include harvest units that cannot be surveyed due to a lack of permission from the landowner. ODF does not currently have authority to enter private land without permission unless a warrant has been granted for specified inspection purposes (ORS 527.715). As a result of the inclusion of harvest units that do not meet the population criteria or cannot be accessed to survey, sample overdraw and additional screening will be conducted to ensure that the desired sample sizes are met.

ODF personnel will proceed down the randomized list of candidate FERNS notifications and screen each notification for indication of harvest completion until the desired sample overdraw is achieved for each survey and stratum. This will result in four sample overdraw lists, one for each landowner type in the planting timeliness and FTG stocking surveys.

Screening will utilize satellite imagery and supplemental information available in FERNS. GIS polygons from FERNS will be compared to Landsat imagery in ArcGIS Pro to determine whether harvest occurred. Landsat bands 6-5-2 (Shortwave IR, Near IR, Blue) will be displayed as red-green-blue to maximize contrast between forest vegetation and bare ground. Where an operation is determined to have occurred, the likely date of completion of the operation is recorded. If Landsat analysis leads to inconclusive results, a GIS overlay of FERNS notification polygons for harvest operations after the reported harvest completion date is also performed. If a FERNS clearcut notification covering the same area is also reported in the years subsequent to the initial notification, and spatially distinct harvests are not present in Landsat imagery, it is assumed that the original harvest notification was not completed and the notification is dropped from consideration.

FERNS will also be queried for site preparation notifications (e.g., herbicide) which is an indicator that harvest occurred. If Landsat imagery from 2022 or later does not indicate that harvest has occurred and there are no indications of site preparation, the notification is dropped from consideration.

Notifications will also be removed from consideration when:

- There is a plan for alternate practice (PFAP) that indicates the overall harvest would exceed 120 acres, or states an alternate plan for reforestation. PFAP documentation may not be clearly identified in the notification, so Stewardship Forester notes and additional documents will be examined when present.

- Operations include a land use conversion. This may be indicated in a FERNS conversion notification, Notification of Operation (NOAP) notes, or Landsat imagery that illustrates conversion activity.

Landowner Contact

Landowners from the sample overdraw lists must be contacted to confirm that harvests meet population criteria and to obtain permission for harvest unit access. To track this process, ODF will construct a contact database that contains all relevant contact information and details about correspondence efforts. Once again, ODF personnel will proceed down the list of candidate units. Landowners are first contacted via electronic mail. If a current email address is not available, a letter will be sent to the landowner's physical address. Based on the landowner response received, the harvest unit will be included or removed from the sample list. After an initial response, further discussion with landowners may be required to confirm that the harvest meets population criteria or to obtain access permission. If no response is received within 7 days (21 days for physical mail), a second email is sent followed by up to two phone calls. If no response is received within 7 days of the second email, any harvest unit notifications owned by the same landowner will be removed from sample list. The cause for removal will be noted in the contact database. This process will continue until the desired sample size is obtained. If harvest units are later removed from the sample for any reason (e.g., due to a change in ownership resulting in loss of access), additional landowners may be contacted using the randomized sample overdraw list.

Sample Size

In prior ODF FPA studies, including the Reforestation Pilot Study, compliance was near 100%. Given that compliance is a binary determination (compliance/noncompliance), it is not feasible to estimate sample sizes that will produce confidence intervals with reliable widths. Therefore, sample sizes (Table 6) were calculated to produce one-sided tolerance intervals that can state the expected minimum percent compliance for at least 80% or 90% of the population with 90% confidence with the equation (NIST 2023, chapter 7.2.6.4):

$$N \cong \frac{1}{4}\frac{(1+p)}{(1-p)}x_{\alpha,4}^2 + \frac{1}{2}$$

where *N* is the estimated sample size, *p* is the proportion of the population, and $x_{\alpha,4}^2$ is the critical value of the chi-square distribution with four degrees of freedom and confidence α. Samples are equally allocated across strata to produce consistent confidence in results.

For tolerance intervals with that can estimate minimum compliance for at least 90% of the population with 90% confidence, sample overdraw will total 223 harvest notifications (Table 6). This was calculated based on landowner response and harvest completion probability from the 2016 and 2017 Implementation Study. In that study, the likelihood that notifications were suitable varied by landowner type, and only 11% of PNI notifications resulted in a successful survey. This was most often due to notifications where harvest did not occur. In the Reforestation Study, this will be mitigated by screening notifications for harvest completion. The sample overdraw will be equal to the desired sample size

multiplied by 1.35 for PI notifications and 4.5 for PNI. This assumes the lowest inquiry response and access permission rates observed from the Implementation Study (PI: 83%; PNI: 25%) and 90% harvest unit suitability.

Table 6. Sample sizes and overdraw for one-sided tolerance intervals that can estimate compliance for at least 80% and 90% of the population with 90% confidence.

Percent of population included in interval	**Sample Size**			**Overdraw**		
	PI	PNI	Total	PI	PNI	Total
80%	18	18	36	25	81	106
90%	38	38	76	52	171	223

Within-unit Sample Selection

Planting Timeliness

Compliance with planting timeliness will be determined by visual inspection. The methods used to collect planting timeliness information is dependent on the desired amount of effort. Two methods are proposed that will be referred to as s*ystematic planting surveys* and s*implified planting surveys*. The chosen survey method must be applied for the entire sample of harvest units.

Systematic Planting Surveys

Systematic planting surveys use a Survey Point sampling design to provide estimates of compliance with planting timeliness. A systematic random sample will be obtained using a grid with at least 15 equidistant Survey Points within the Harvest Unit Boundary. The number of Survey Points was calculated to produce at least 10 samples to reliably estimate if planting occurred throughout harvested area suitable for planting. This was informed by the Reforestation Pilot Study that observed approximately 34% of Survey Points were unsuitable for planting. Each point will be visited to determine suitability for planting. If the point is suitable for planting, the surveyor will record whether planting has occurred in the immediate vicinity along with the species planted.

Simplified Planting Surveys

Simplified planting surveys use a visual inspection of the entire harvest unit to estimate compliance with planting timeliness. The surveyor will then walk the harvested area and look for evidence of planting. The surveyor will record whether planting occurred and the dominant planted species. The survey is complete when the entire unit has been visually inspected. Binoculars, spotting scopes, or similar may be used to assist with the survey.

Free To Grow Stocking

In each Harvest Unit Boundary, a systematic random sample will be obtained using a grid with at least 27 equidistant Survey Points that will be visited to determine suitability for a Survey Plot (Figure 7). The

number of Survey Points was calculated to produce reliable one-sided tolerance intervals to estimate the minimum stocking level for at least 80% of the harvest unit with 90% confidence (18 samples), and informed by plot suitability data from the Reforestation Pilot Study. Survey Points will function as the center of the Survey Plots, which will have a 16.7-foot radius (horizontal distance).

If the Survey Point is unsuitable for a Survey Plot due to a road or proximity to Harvest Unit Boundary, an offset procedure will be applied in the field to obtain a suitable location for a Survey Plot. If the Survey Point is unsuitable for any other reason (e.g., within an RMA), no survey will be conducted. Results from the Reforestation Pilot Study indicate that 34% of points were unsuitable for surveying, and an offset procedure for roads and unit boundaries could reduce this to 19%. Therefore, we expect at least 20 successful Survey Plots within each harvest unit, greater than the 18 required for the specified tolerance interval.

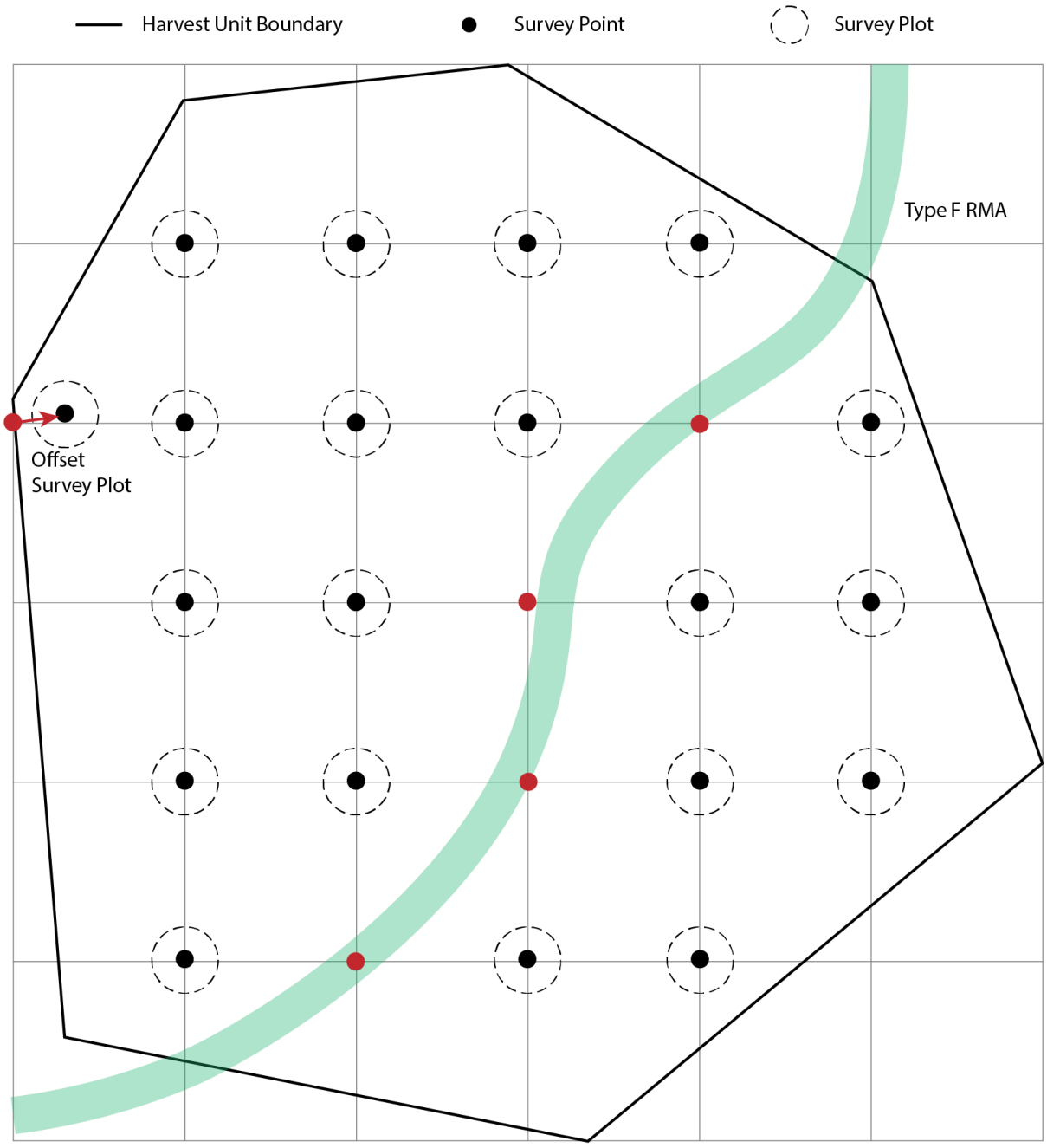

Figure 7. Conceptual diagram of survey area. Red dots indicate Survey Points that would be unsuitable for surveying.

Harvest Unit Access

The landowner (or agent of the landowner) will be contacted prior to accessing the harvest unit, unless the landowner has explicitly indicated that such contact is unnecessary. During this contact, permission will be reaffirmed to visit the unit on the intended date. Access routes and any additional considerations

(e.g., gates or dangerous animals) will be communicated at this time. All landowner requests will be documented and included with field data.

Landowner contact must occur within two weeks prior to the intended field visit unless the landowner indicates otherwise. The primary contact method will be a phone call. The surveyor will supplement this with written communication (email or letter) if verbal contact is not established within one day of the initial phone call. For timeliness, letters should request a response via phone or e-mail.

If the landowner does not respond within one week of the initial phone call, the surveyor will make two additional phone calls to the landowner. All attempts to contact the landowner will be documented and included with field data. A log will be kept to document phone calls and surface letters, with the accompanying result. For e-mail, copies of the communication will be the most appropriate documentation. If all contact attempts are unsuccessful, or if the landowner revokes permission to access land, the next uncontacted harvest notification from the randomized sample overdraw list will be selected, and the surveyor will request permission to access the alternate site's harvest unit following the above procedure. ODF will note this change in the contact database, along with reasons leading to the change.

Field Survey Protocol

Field survey methods for planting timeliness and FTG stocking are detailed below. The survey design and data collection methods are fixed; however, harvest unit access methods and other logistical considerations are subject to minor modification for safety and feasibility.

Planting Timeliness

To facilitate planting timeliness surveys, surveyors will be provided with:

- Digital field maps with associated metadata. Maps and metadata will contain Harvest Unit Boundaries and the location of designated Survey Points in latitude and longitude format (Figure 7 and **Error! Reference source not found.**)
- Field Survey Protocol section of this document
- Planting timeliness survey data forms (see **Error! Reference source not found.**)
    - **Note:** The free to grow stocking data forms can be used as a template for systematic planting surveys.
- Copies of signed permission forms
- Access route information
- Any special instructions and considerations from the landowner

In addition, the following equipment is required:

- GPS-enabled handheld device capable of accuracy within 16 feet
- Digital camera that collects and stores spatial metadata
- Systematic planting surveys: laser rangefinder with horizontal distance calculation and accuracy within 1 foot
- Simplified planting surveys: binoculars, spotting scope, or similar
- Simplified planting surveys: digital or physical map of harvest unit for markup

Systematic Planting Surveys

Order of Operations

A summary of the systemic planting survey protocol is as follows:

1. Navigate to the harvest unit and complete a harvest unit evaluation.
2. Navigate to a Survey Point.
3. Determine Survey Point suitability.
4. If suitable, record if planting occurred and the dominant species planted.
5. Navigate to the next Survey Point and repeat the process, starting at step 3, until all Survey Points have been visited.

Harvest Unit Evaluation

After navigating to the harvest unit, the surveyor will find a readily accessible vantage point and perform a 5-to-10-minute visual examination of the harvest unit. The results of this examination will be used as supplementary information outside of statistical analysis and compliance determination. During this examination, the surveyor will take at least one georeferenced photograph documenting site conditions. The surveyor will answer the following questions, based on visual impression:

1. Are there substantial differences between the Harvest Unit Boundary on the provided map and the observed harvest area?
2. Was stocking reduced to a level requiring reforestation?
3. Over how many acres was stocking reduced to levels requiring reforestation?

Determine Survey Point Suitability, Record Planting

Using a GPS-enabled device, surveyors will navigate to a Survey Point. Survey Points will first be evaluated for suitability by observing the area within the Survey Plot radius. Survey Points are considered unsuitable for a Survey Plot if they are: within 20 feet of a road, within 20 feet of a Harvest Unit Boundary, within 20 feet of a Type F RMA, or unsuitable for growing trees. Additionally, unharvested areas exceeding ¼ acres (including meadows with no evidence of harvest) will be considered unsuitable. Unharvested areas are characterized by groups of unharvested trees with undisturbed understory vegetation.

If a Survey Point is unsuitable, the surveyor will record the code indicating the reason (Table 7) and navigate to the next point. If the Survey Point is suitable, the surveyor will record whether evidence of planting can be observed within 23.5 feet of the point (1/25th acre survey plot area), measured by laser rangefinder if necessary. The surveyor will then record the dominant tree species planted. This process will be repeated until surveys have been conducted at all suitable Survey Points within the Harvest Unit Boundary.

Table 7. Suitability codes for Survey Points during systematic planting surveys.

Code	Description	Procedure
S	Suitable	Conduct survey
XS	Trees cannot be grown because the location is on stone (>1/3 of survey plot area)	Move to next point
XW	Trees cannot be grown because location is on water or in a wetland (>1/3 of survey plot area)	Move to next point
XO	Trees cannot be grown for other reason	Describe in notes; move to next point
RM	Survey Plot is within 20’ of an RMA	Move to next point
RD	Survey Plot is within 20’ of a Road	Move to next point

UH	Location is unharvested (>1/3 of survey plot area)	Note how the unharvested condition was determined; move to next point
BO	Survey Point outside of Harvest Unit Boundary	Move to next point
OT	Another condition (e.g., unable to access safely) makes the plot location unsuitable, but trees are capable of being grown at the location	Describe in notes; move to next point

Simplified Planting Surveys

Order of Operations

A summary of the simplified planting survey protocol is as follows:

1. Navigate to the harvest unit and complete a harvest unit evaluation.
2. Conduct a visual inspection of the entire harvest unit, marking the inspected areas on a map of the harvest unit.
3. Record whether planting occurred throughout the unit, estimate the percent of total planting by tree species.

Harvest Unit Evaluation

After navigating to the harvest unit, the surveyor will find a readily accessible vantage point and perform a 5-to-10-minute visual examination of the harvest unit. The results of this examination will be used as supplementary information outside of statistical analysis and compliance determination. During this examination, the surveyor will take at least one georeferenced photograph documenting site conditions. The surveyor will answer the following questions, based on visual impression:

1. Are there substantial differences between the Harvest Unit Boundary on the provided map and the observed harvest area?
2. Was stocking reduced to a level requiring reforestation?
3. Over how many acres was stocking reduced to levels requiring reforestation?

Visual Inspection

The surveyor will proceed walk the area of the harvest unit suitable for planting, not including RMAs; the amount of area covered should be sufficient to obtain a reliable determination that planting or did or did not occur throughout the entire harvested area. During the survey, the surveyor will clearly mark the areas visually inspected on a physical or digital map of the harvest unit that includes the Harvest Area Boundary. The survey is complete when the entire harvested area has been inspected, verified by the harvest unit map. This map will be a data product delivered with survey results. Binoculars, spotting scopes, or similar may be used to assist with harvest unit coverage. The surveyor will record whether there is evidence of planting throughout the unit, along with planted tree species and approximate the percent of the unit planted by species.

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Free To Grow Stocking

To facilitate field surveys, surveyors will be provided with:

- Digital field maps with associated metadata. Maps and metadata will contain Harvest Unit Boundaries and the location of designated Survey Points in latitude and longitude format (Figure 7 and **Error! Reference source not found.**)
- Field Survey Protocol section of this document
- FTG stocking survey data forms (see **Error! Reference source not found.**)
- Copies of signed permission forms
- Access route information
- Any special instructions and considerations from the landowner

In addition, the following equipment is required:

- GPS-enabled handheld device capable of accuracy within 16 feet
- Surveyor measuring tape (e.g., Spencer) with imperial marking
- Laser rangefinder with horizontal distance calculation and accuracy within 1 foot
- Reflective post for rangefinder
- Digital camera that collects and stores spatial metadata
- Red paint and/or biodegradable flagging

Order of Operations

A summary of the FTG survey protocol is as follows:

4. Navigate to the harvest unit and complete a harvest unit evaluation.
5. Navigate to a Survey Point.
6. Determine suitability for a Survey Plot, offset if applicable.
7. Delineate Survey Plot and mark location.
8. Tally FTG trees by size category.
9. Navigate to the next Survey Point and repeat the process, starting at step 3, until all Survey Points have been visited.

Harvest Unit Evaluation

After navigating to the harvest unit, the surveyor will find a readily accessible vantage point and perform a 5-to-10-minute visual examination of the harvest unit. The results of this examination will be used as supplementary information outside of statistical analysis and compliance determination. During this examination, the surveyor will take at least one georeferenced photograph documenting site conditions. The surveyor will answer the following questions, based on visual impression:

1. Are there substantial differences between the Harvest Unit Boundary on the provided map and the observed harvest area?

2. Was stocking reduced to a level requiring reforestation?
3. Over how many acres was stocking reduced to levels requiring reforestation?
4. Was planting attempted?

Determine Survey Plot Suitability

Using a GPS-enabled device, surveyors will navigate to a Survey Point. Survey Points will first be evaluated for suitability by observing the area within the Survey Plot radius. Survey Points are considered unsuitable for a Survey Plot if they are: within 20 feet of a road, within 20 feet of a Harvest Unit Boundary, within 20 feet of a Type F RMA, or unsuitable for growing trees. Additionally, unharvested areas exceeding ¼ acres (including meadows with no evidence of harvest) will be considered unsuitable. Unharvested areas are characterized by groups of unharvested trees with undisturbed understory vegetation.

If a Survey Point is unsuitable, the surveyor will record the code indicating the reason (Table 8). If the Survey Point is unsuitable due to proximity within 20 feet of a road or Harvest Unit Boundary, the Survey Point may be offset. The offset procedure is as follows:

- For Survey Points within 20 feet of roads, the surveyor will navigate perpendicular to the road in the direction nearest to the road edge and place the new Survey Point at the first suitable location between 20 and 50 feet from the road edge, measured in 10-foot increments. If no suitable point is found, the surveyor will note the reason and navigate in the opposite direction perpendicular to the road to the first suitable location between 20 and 50 feet from the road edge, measured in 10-foot increments. If both directions are unsuitable for any reason, the surveyor will move to the next Survey Point.

- For Survey Points within 20 feet of the Harvest Area Boundary, the surveyor will navigate to the first suitable point between 20 and 50 feet from the boundary in the direction perpendicular to the boundary and toward the interior of the harvested area, measured in 10-foot increments. If suitable, a Survey Point will be placed and survey conducted. If unsuitable, the reason will be noted and the surveyor will move to the next Survey Point.

The location of all offset Survey Points will be recorded with a handheld GPS device in latitude and longitude format. If the Survey Point is unsuitable for any other reason, the surveyor will move to the next Survey Point.

Table 8. Suitability codes for Survey Points during free to grow stocking surveys.

Code	Description	Procedure
S	Suitable	Delineate Survey Plot
XS	Trees cannot be grown because the location is on stone (>1/3 of survey plot area)	Move to next point

XW	Trees cannot be grown because location is on water or in a wetland (>1/3 of survey plot area)	Move to next point
XO	Trees cannot be grown for other reason	Describe in notes; move to next point
RM	Survey Plot is within 20’ of an RMA	Move to next point
RD	Survey Plot is within 20’ of a Road	Offset point
UH	Unharvested area >1/3 of plot.	Note how the unharvested condition was determined; move to next point
BO	Survey Point outside of Harvest Unit Boundary	Offset point if within 20’ of boundary, otherwise move to next point
OT	Another condition (e.g., unable to access safely) makes the plot location unsuitable, but trees are capable of being grown at the location	Describe in notes; move to next point

Delineate Survey Plot

At suitable Survey Points, the surveyor will delineate the Survey Plot (Figure 8). Survey Points will be marked as the Survey Plot center with a 2.0 foot “X” using red paint and assigned a Survey Plot number. Plots may be marked with flagging when explicit permission is given by the landowner. From this center point, a 16.7-foot radius (horizontal distance) circular plot will be measured using a laser rangefinder. A measuring tape may be used to delineate the survey plot when necessary (e.g., no clear line of sight to Survey Point). Surveyors will record the whether laser rangefinder or tape was used to delineate the plot.

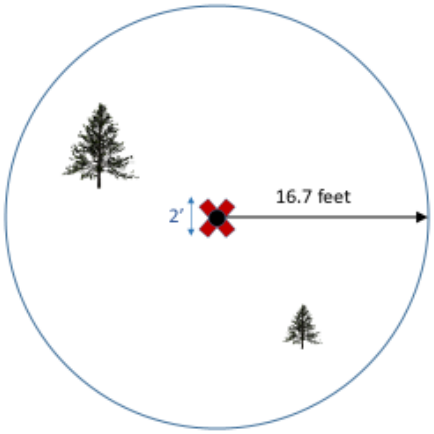

Figure 8. Diagram of Survey Plot.

Tally Free To Grow Trees

Trees that meet free to grow status are defined as “vigorous, healthy, and dominant over undesired competing vegetation”. Seedlings, saplings, pole-sized trees, and trees over 11 inches DBH meeting the following standards are considered free to grow (*definition is subject to change prior to field surveys*):

1. Potential for continued height growth consistent with the site’s productivity;

2. Freedom from damage by insects, disease, fire, wildlife, weather, or logging that would prevent growth to site potential[1]:
    a. Does not lean more than 30 degrees from vertical
    b. Does not have a broken, dead, or missing main stem;
    c. For trees 8 inches DBH or larger, have not suffered scrapes from timber harvesting that penetrate the cambium on more than one half of the stem circumference at any point on the tree;
    d. For trees less than 8 inches DBH, have not suffered scrapes from timber harvesting that penetrate the cambium on more than one third of the stem circumference at any point on the tree; and
    e. Have not suffered visible severing, mutilation, or exposure from timber harvesting of more than one third of the root spread.
3. Generally, at least one-third of the tree height in full, live crown, though on some sites the dominant tree cohort may have less than a one-third live crown and retain adequate vigor. Surveyor should examine adjoining timber. At minimum, free to grow tree should have more than ten percent live crown.
4. Taller than, and out-competing any grass, shrubs, or undesired trees growing within a ten (10) foot radius from the tree.

The surveyor will tally the number of FTG trees, by species and size class (seedling (< 1 in DBH), sapling or pole (1 to 10 in DBH), and sawtimber (11 in DBH and greater), within the Survey Plot. From a marked starting point, trees will be tallied in a clockwise direction. When a rangefinder is used to determine the plot radius, the distance from plot center to trees within one foot of the plot edge will be measured with a tape to ensure that the tree is within the survey plot. If the center of the tree stem is within the plot, then it will be tallied.

Once the first successful plot has been collected, the surveyor can move to the next Survey Point. This process will be repeated until surveys have been conducted at all suitable Survey Points within the Harvest Unit Boundary. All fields on the data collection forms should be filled out as follows:

Survey Point: Record the survey point number associated with the tally

Suitability Code: Indicate suitability code from

Offset Location: Record the coordinates of the offset survey point (Lat/ Lon)

Suitability Notes: Record any notes relevant to the suitability of the survey point

Tree Tally: Tally of the free to grow trees in each size category

[1] Note that we are not collecting data on trees exhibiting these damages, but rather data for trees that are free of these damages. Data that will be collected are described in Appendix 1.

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Data Products

The surveyor must provide the following deliverables to ODF, according to the schedule listed in the Statement of Work. The surveyor may collect data either in electronic or hardcopy format. When possible, data will be backed up prior to the next field day. Hardcopy field data will be converted to electronic spreadsheets in the office. Data to be collected, with suggested formats, include the following:

- Documentation of surveyor efforts to contact landowners.
- Tabular data corresponding to the survey form. These data must include fields listing Site ID and plot number, so that the tabular data may be joined to the GIS data. Provide these in MS Access or ESRI-compatible format.
- Harvest Unit Boundaries prepared by the surveyor, where they are different from boundaries provided prior to field survey. Provide these in ESRI geodatabase or shapefile format.
- General notes, including directions for getting to unit, access considerations, and landowner requests.
- Field notes that provide information that assists with the understanding of surveyor procedures or site-specific conditions. Index these by site number and plot number. Provide these in tabular format (e.g., MS Access, csv).
- At least one photograph per unit displaying site conditions. If there are complications that limit the ability of the surveyor to perform the survey, or that add to understanding of the unit's reforestation, these should also be included. These photographs must be accompanied by a description of the condition that the photograph is supposed to display. GPS location information must accompany the pictures. If the metadata does not indicate the direction that the camera was facing, provide this information in the notes. Provide a table indexed to Site, Plot # (if applicable), and photograph number describing the purpose of each photograph.
- For simplified planting surveys: a harvest unit map that clearly marks that the entire unit was visually inspected.

Quality Control

Replicate planting and FTG stocking surveys will be conducted to ensure data accuracy. A random subset equal to 10% of sampled harvest units will be surveyed a second time by ODF personnel. Replicate surveys will follow the same field methods appropriate for the survey type and be completed for the entire harvest unit. Data collected during initial and quality control surveys will be analyzed and compared to confirm concordant compliance determinations. If compliance determinations are not consistent, then an additional quality control survey will be conducted at a different harvest unit surveyed by the initial survey party. If this subsequent quality control survey reveals continued inconsistency in compliance, then ODF will conduct remediation actions to mitigate the potential for

systematic error, such as additional training or a supervised survey at a model site. Additionally, when compliance determinations between initial and quality control surveys are not consistent, results from quality control surveys will be used for analysis and reporting.

Analysis

Planting Timeliness

Data collected during planting timeliness surveys will be analyzed and summarized based on the conducted survey protocol.

Systematic Planting Surveys

If systematic planting surveys were applied for the entire sample of harvest units, compliance with planting per OAR 629-610-0040 (3) will be estimated for clearcut harvest units that meet all population criteria. Harvest unit compliance will be determined based on data collected at Survey Points. If evidence of planting was observable near all survey points suitable for planting with acceptable species, the unit will be considered in compliance with OAR 629-610-0040 (3). Tree species data recorded during surveys will be designated as acceptable or unacceptable based on a region-specific species list developed by ODF based on OAR 629-610-0050 guidance (**Error! Reference source not found.**).

Compliance by landowner type will be estimated by dividing the number of units in compliance by the sample size within the stratum. Percentage compliance will also be calculated across landowner type strata. Compliance across strata will be calculated by weighting compliance by the estimated population size within each stratum. The number of harvest units within strata will be estimated using the total number of FERNS notifications identified during the sample draw process multiplied by the likelihood that FERNS notifications met population criteria, based on results from the additional suitability screening after sample overdraw. Uncertainty surrounding compliance estimates will be quantified using one-sided tolerance intervals for binomial proportions (e.g., 'tolerance' package for program R) to estimate the expected percent compliance for at least 80% or 90% of the population with 90% certainty, depending on the sample size of harvest units.

Simplified Planting Surveys

For simplified planting surveys, units will be considered in compliance if planting with acceptable species was observed throughout the entire harvested area that is suitable for planting. Tree species data recorded during surveys will be designated as acceptable or unacceptable based on a region-specific species list developed by ODF based on OAR 629-610-0050 guidance (**Error! Reference source not found.**).

Compliance by landowner type will be estimated by dividing the number of units in compliance by the sample size within the stratum. Percentage compliance will also be calculated across landowner type strata. Compliance across strata will be calculated by weighting compliance by the estimated population

size within each stratum. The number of harvest units within strata will be estimated using the total number of FERNS notifications identified during the sample draw process multiplied by the likelihood that FERNS notifications met population criteria, based on results from the additional suitability screening after sample overdraw. Uncertainty surrounding compliance estimates will be quantified using one-sided tolerance intervals for binomial proportions (e.g., 'tolerance' package for program R) to estimate the expected percent compliance for at least 80% or 90% of the population with 90% certainty, depending on the sample size of harvest units.

Free To Grow Stocking

Data collected during FTG stocking surveys will be analyzed to estimate compliance with minimum stocking (OAR 629-610-0040 (4)) for clearcut harvest units that meet all population criteria. FTG tree count data from Survey Plots will be used to estimate FTG stocking in trees per acre (TPA) for each harvest unit. TPA will be calculated by multiplying counts in each size class to a one-acre area and converting to seedling equivalent using methods described in OAR 629-610-0020(7).

The minimum required TPA will be determined for each harvest unit using the CFSC that applies to the unit that corresponds to values in OAR 629-610-0020. Maps from the Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) will be used to determine CFSC, where available. SSURGO provides CFSC data at 1:24,000 resolution. If SSURGO data is not available for the harvest unit, then the NRSC State Soil Geographic Database with 1:250,000 resolution will be used. If neither NRCS sources are available for a harvest unit, then Department of Revenue site capability information with 40-acre resolution will be used to determine CFSC. If multiple CFSC values are present within a harvest unit, then the CFSC value that applies for a majority of the unit will be applied.

Harvest unit compliance will be determined by comparing the lower bound of a one-sided tolerance interval to minimum stocking requirements. When the lower bound of the tolerance interval is equal to or greater than the minimum required TPA, the unit will be considered in compliance. The tolerance interval will be calculated using 90% confidence (alpha = 0.1) and 80% population coverage. This is intended to be consistent with FPA Guidance that minimum stocking levels must be met for at least 80% of the harvest unit (OAR 629-610-0000 Guidance). Data from the Reforestation Pilot Study indicated that tree count and associated TPA data are not normally distributed and often heavily skewed to the right. Therefore, TPA data will be examined post-data collection to ensure that the proposed analytical method to estimate compliance is appropriate, and to obtain a suitable distribution for the tolerance interval calculation. The 'tolerance' package for the statistical program R has numerous options for parametric and nonparametric tolerance interval calculation.

The percent of harvest units in compliance will be estimated within and across landowner type. The number of harvest units within strata will be estimated using the total number of FERNS notifications identified during the sample draw process multiplied by the likelihood that FERNS notifications met population criteria, based on results from the additional suitability screening after sample overdraw. Values reported across strata will be calculated by weighting statistics based on estimated population size within each stratum. Uncertainty surrounding compliance estimates will be quantified using one-sided tolerance intervals for binomial proportions (e.g., 'tolerance' package for program R) to estimate

the expected percent compliance for at least 80% or 90% of the population with 90% certainty, depending on the sample size of harvest units.

Reporting

ODF will document the findings of the Reforestation Study in a report. The report will address each study question, describe methods, and will discuss overall observations from the annual process as well as presenting the summary data and estimated percent compliance. Compliance will also be reported annually to the Oregon legislature.

References

NIST. 2023. NIST/SEMATECH e-Handbook of Statistical Methods. https://www.itl.nist.gov/div898/handbook/index.htm.